Second Quarterly Progress Report

Contract NAS 3-4103

Experimental and Analytical Investigation of an MGD Power Generation Duct

Period Covered:

October 11, 1963 to January 11, 1964

Project Manager: A. Sherman

Project Scientist: Dr. F. H. Shair
Telephone Number: 215-969-2676

January 20, 1964

Prepared for Lewis Research Center, NASA, Cleveland 35, Ohio

Space Sciences Laboratory
General Electric Company
Box 8555, Philadelphia 1, Pa.

The work covered by this report was accomplished under NASA Contract NAS 3-4103. However, this report is being published and distributed prior to NASA review. The publication of this report does not constitute approval by NASA of the results contained herein. It is published for exchange and stimulation of ideas.

The work reported was sponsored by the Lewis Research Center. Dr. H. Kosmahl is the cognizant scientist for NASA.

INTRODUCTION

Contract NAS 3-4103 provides for an investigation of the achievement of high electrical conductivities in an MHD plasma by non-thermal ionization techniques. The work will include analytical investigations as well as experiments with the M-4 MGD generator. Specifically, non-equilibrium techniques making use of metastables, high pressure glow discharge, and electron beam ionization will be studied. The objective will be a demonstration of sustained power generation in an MGD generator using non-equilibrium techniques with power densities on the order of 10 MW/M^3.

Task Summary

The following main tasks were accomplished during the second quarter period:

1. All components associated with the electron beam have been received and are being checked out. The cathode has been successfully operated up to 50 Kev in argon, nitrogen and in helium. The cathode was operated between 2 and 35 ma. (The various drawings associated with the electron beam are discussed in detail below.)

2. Two new test sections have been designed in order to eliminate the cesium attack on the alumina insulators. The first new test section is nearly finished and will be used with the electron beam MHD experiments. These tests will begin within the next two weeks.

3. Five intermediate temperature (900-1200^{o}C) experiments were conducted, and the data is being reduced. Non-equilibrium conductivities were observed; however, cesium attack upon the alumina insulator made the data difficult to reproduce. This problem has been solved with the new test sections; the new dense alumina insulators were tested and resisted any visible cesium attack.

4. Design of an air-tight exhaust system is complete and will be installed in the M-4 during the next month.

Electron Beam Components

(Dr. H. E. Hall)

Figure 1 is a drawing of the "Tee Assembly" which is the adaptor section necessary to modify the existing MHD duct for the introduction of an electron beam. The material (nickel) was chosen so as to keep non-magnetic materials along the beam path. The two threaded holes at the junction of the tee are necessary for the introduction of the tubing through which gas will be introduced to form a layer of cool gas on the duct side of the foil separating the duct from the electron beam assembly vacuum. Figures 2A, B, C & D are the component drawings of the foil retainer assembly.

The "Foil Retainer" (see Figure 2A) is a cap which holds the foil over the electron beam exit apperture. Holes have been drilled to accept slotted tubes for argon cooling. The cover opening is much larger than the exit apperture so as not to intercept any of the electron beam which is scattered by penetrating the foil.

The "Water-Cooled Apperture Slit" (see Figure 2B) shows the pieces from which the exit apperture was constructed. The circular groove in the piece mates with the circular ridge in the foil retainer cap so as to give a vacuum seal with the foil in place. The two-piece construction was needed to give the proper water flow channel to insure proper cooling.

Figure 2C. "Tube Details." Here are given the details of the path of water flow from the "Water Passage Flange" (Figure 2D) to the apperture cooling and back as well as the separators needed to separate the inlet from the exit passage. The water passages are designed such that the total cross sectional area presented by the five of them, for each flow direction, equals the cross sectional area of the inlet.

Figure 2D. "Water Passage Flange." The water inlet and exit ports are given as well as the o-ring grooves and bolt holes needed for mounting the total assembly.

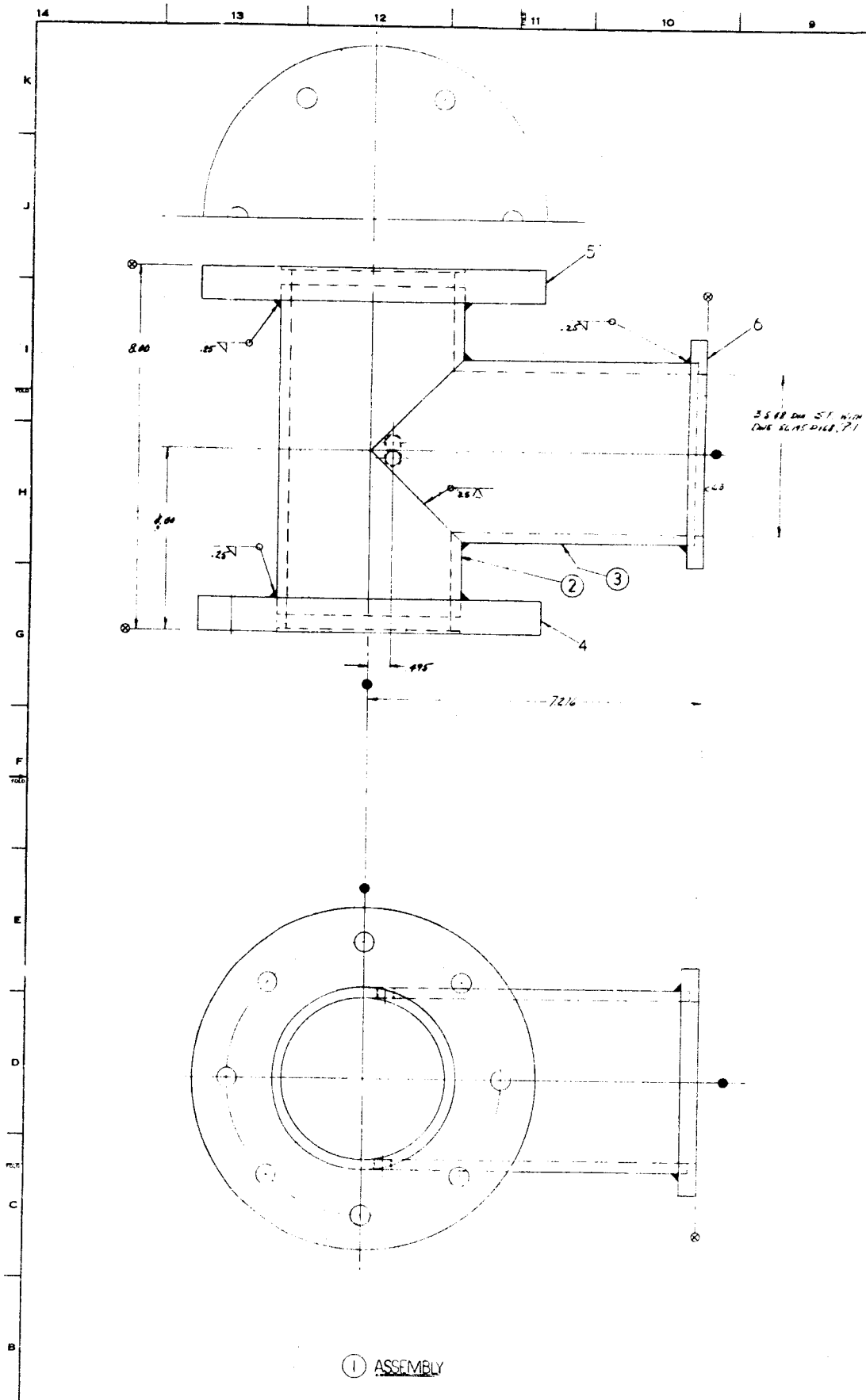
Figures 3A and 3B are detailed drawings of the pumping station.

Figure 3A. "Flange Assembly." This is designed to mate with a 2" gate valve.

Figure 3B. "Electron Beam Details." In this block is a view port which allows one to see the beam cross over point which is visible due to the presence of the working gas pressure. The two other side ports lead to the gate valve flange and the vacuum gauge holder.

Figures 4A, B, C & D are the drawings of the magnetic section, including (4A) "Adapter", (4B), "Adapter Assembly", (4C) "Flange Detail" and (4D) "Adjusting Block." The design is such as to allow the magnetic coil (Figure 5A) to be outside of the evacuated region, thereby easing cooling requirements. The "Adjusting Blocks" (Figure 4D) are needed to allow fine adjustment of the focusing coil position relative to the central ray of the beam.

Figures 5A and B, "Magnet" and "Magnet Housing" respectively, give the specifications for the focusing coil and its shroud. Also noted on Figure 5B are the heat treating requirements for the Armco iron used in the shroud. Figure 6, the "Water Cooled Apperture Assembly" is used as the image for the electron optics which follow. It is water cooled since it will intercept a portion of the beam exiting through it from the cathode housing.


5
6
4
2
3
8.00
6.00
.85
.25
.25
.25
4.95
7.24
3.500 Dia ST. WITH
DWG SCALE DIA. .71

① ASSEMBLY

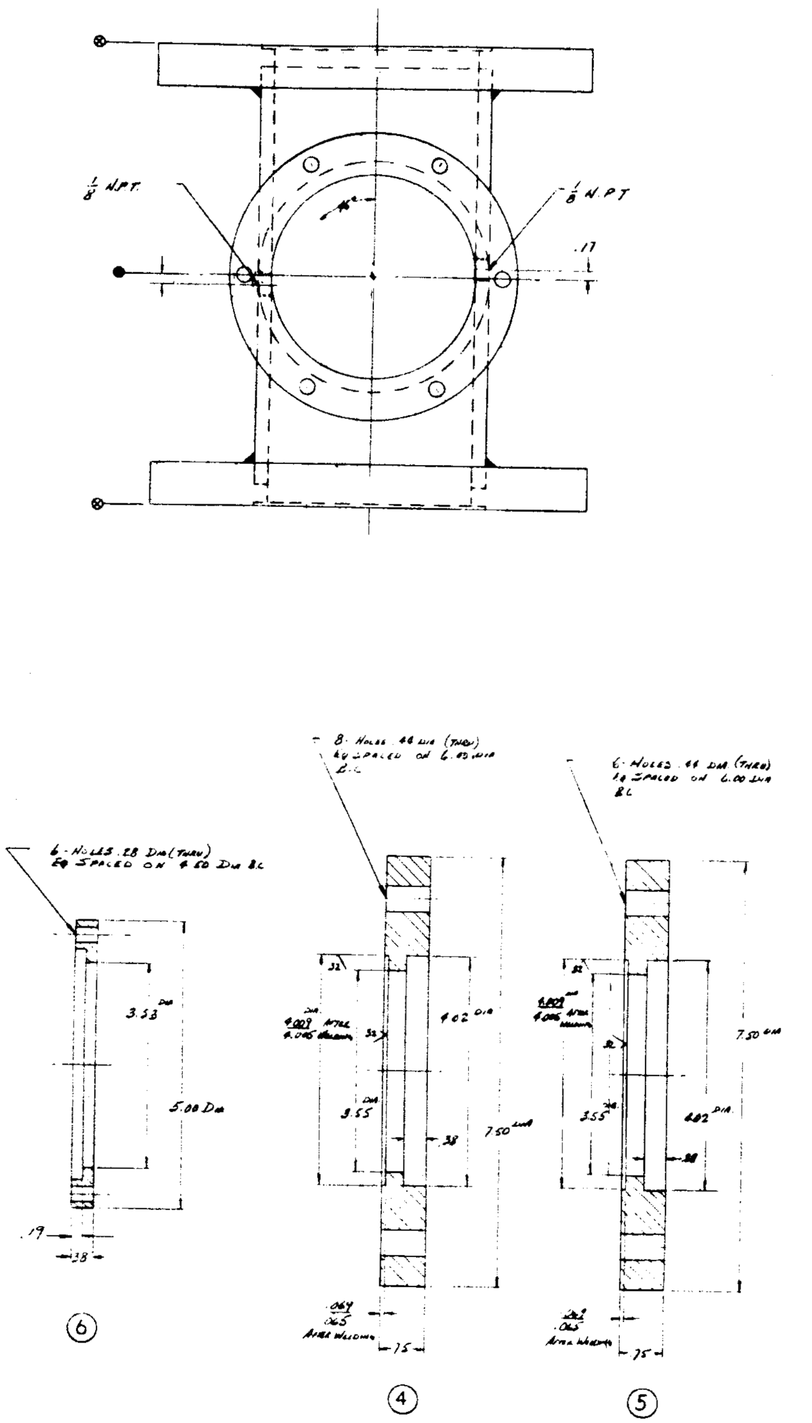


FIGURE 1

Note
1- Break All Sharp Edges
2- All Finish Machining Is To Be Done After Welding
3- ℄ Marked ● Should Be Perpendicular To Each Other Within .005 T.I.R.
4- Surfaces Marked ⊗ Are To Be Parallel Or Perpendicular To ℄ Marked ● Within .005 T.I.R.

Qty	Item	Ident No	Description	Material
1	6		Flange	Nickel
1	5		Flange	Nickel
1	4		Flange	Nickel
1	3		Pipe 3½" Nom Sch 40 X 7.08 Lg	Nickel
1	2		Pipe 3½" Nom. Sch 40 X 7.25 Lg	Nickel
X	1		Assembly	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES — TOLERANCES ON:
2 PLACE DECIMALS ±.01
3 PLACE DECIMALS ±.005
ANGLES ± 0°-30'
ALL SURFACES 125√

MATERIAL —

SIGNATURES	DATE
[signature]	1-10-6?
[signature]	1-15-6?
RPM	1-15-6?
[signature]	1-17-6?

GENERAL ELECTRIC
MSD-SSL DEPT LOC. Valley Forge, Pa

TITLE
TEE ASSEMBLY

CONTRACT NO
CODE IDENT NO | SIZE E | DWG NO. 56145E174
SCALE FULL | WT | SHEET OF

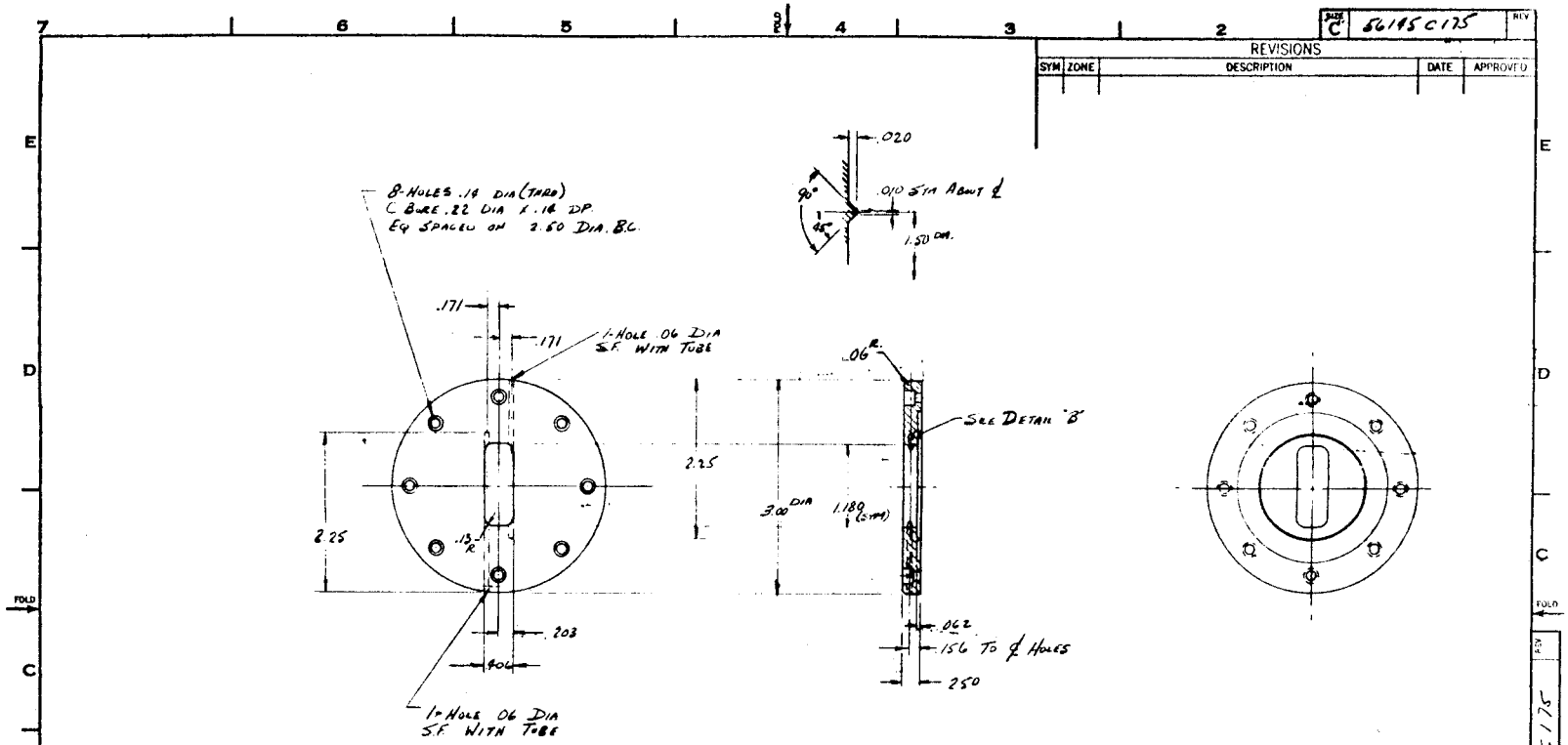


FIGURE 2a

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES— TOLERANCES ON: 2-PLACE DECIMALS ± .01 3-PLACE DECIMALS ± .005 ANGLES ± 0°30' ALL SURFACES 125	SIGNATURES	DATE
MATERIAL— COPPER OR COMP. HIGH CONDUCTIVITY OXYGEN FREE	DRAWN R.P. Spangler	1-14-65
	CHECKED D. Stark	1-15-65
	ISSUED A. E. Hall	1-17-65

GENERAL ELECTRIC
MSD-55L DEPT LOC VALLEY FORGE PA

TITLE: FOIL RETAINER

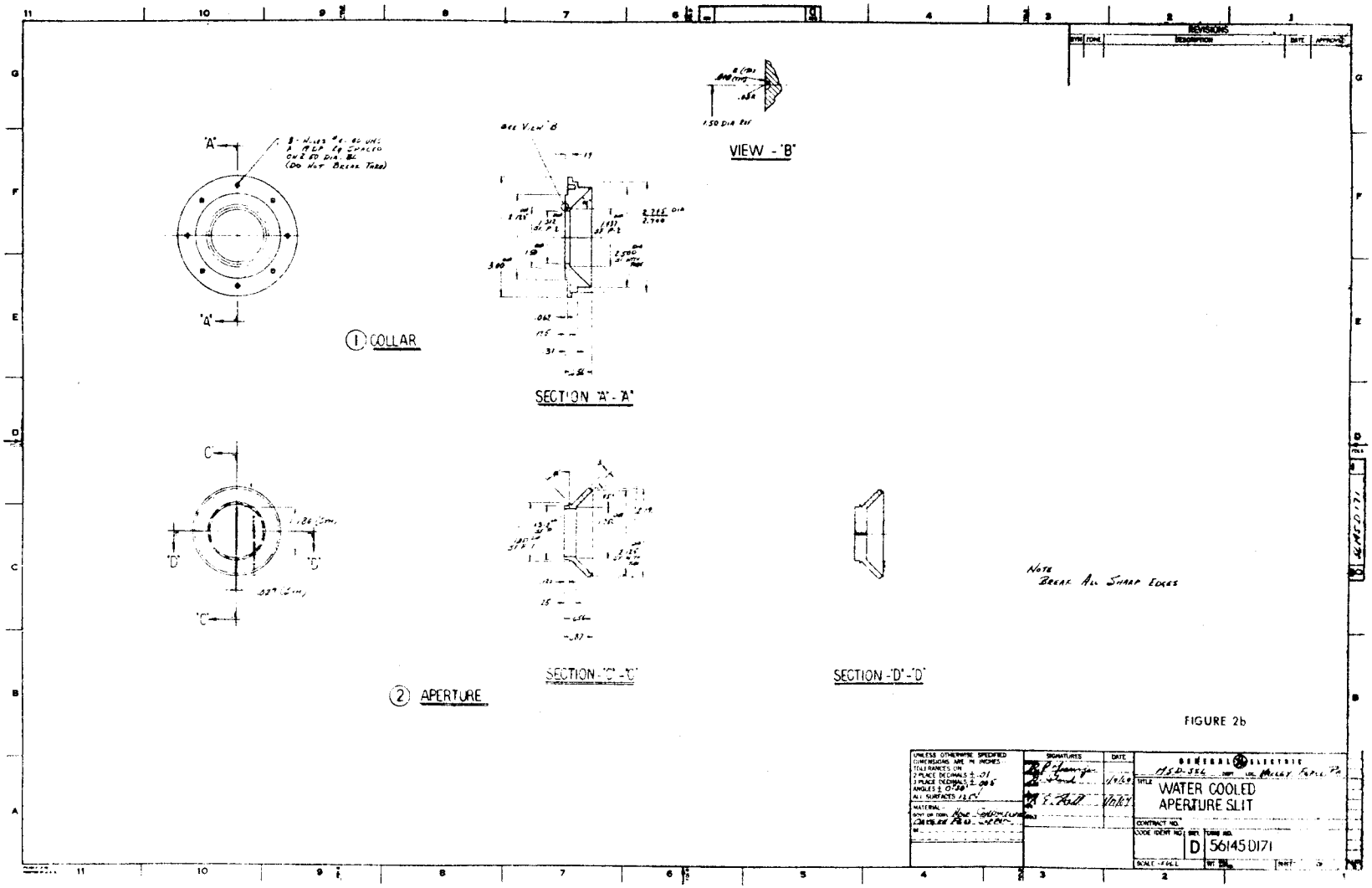
CONTRACT NO.

CODE IDENT NO	SIZE	DWG NO.
	C	56145C175

SCALE FULL | WT SCALE ACTUAL | SHEET OF

SIZE C 56145C175 REV

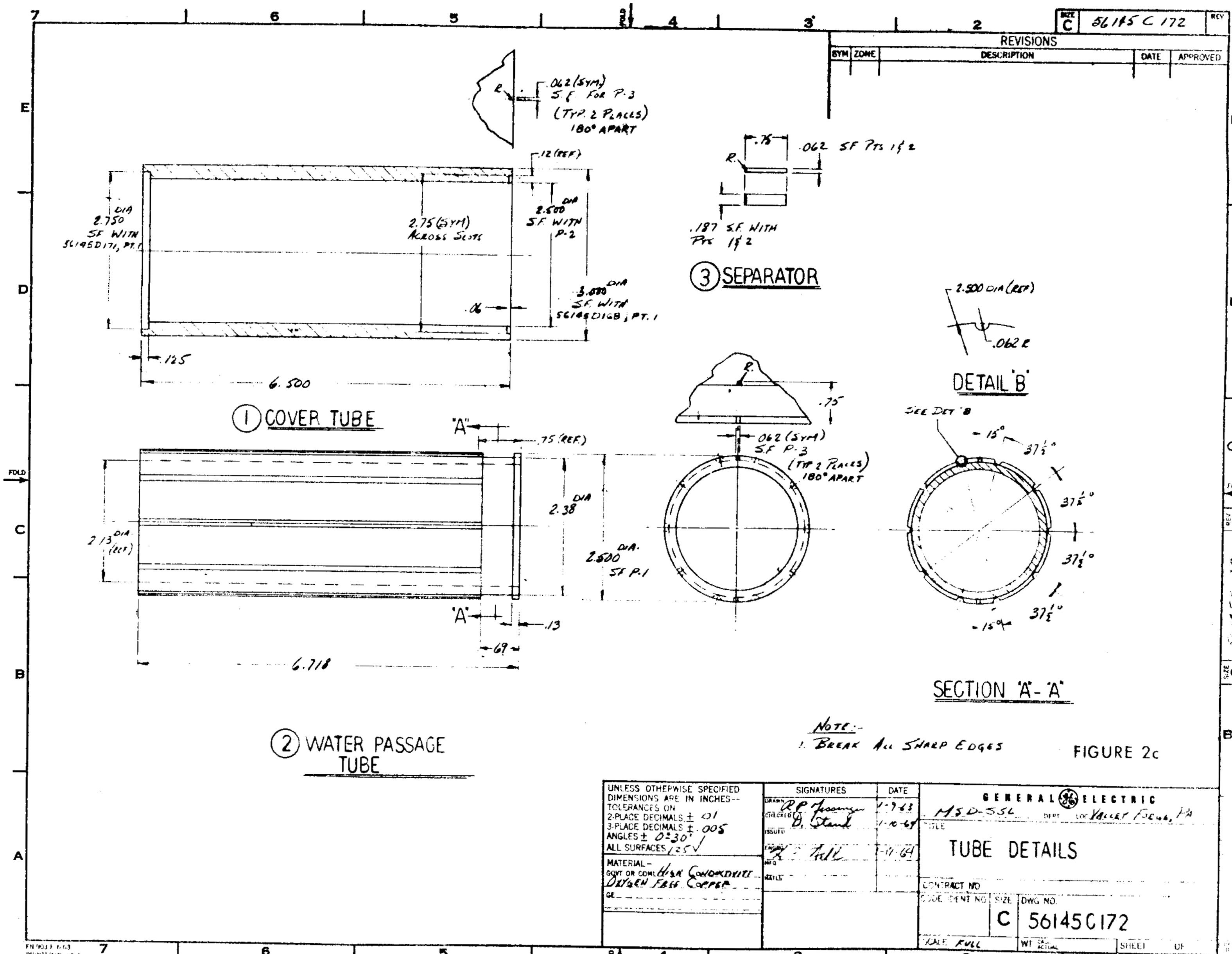
FN 903 F 6-63
PRINTED IN U.S.A.



① COLLAR

② APERTURE

FIGURE 2b


C 56145 C 172
REVISIONS
SYM ZONE DESCRIPTION DATE APPROVED
.062 (SYM) S.F. FOR P-3 (TYP. 2 PLACES) 180° APART
.12 (REF.)
2.750 DIA SF WITH 56145D171, PT. I
2.75 (SYM) ACROSS SLOTS
2.500 DIA SF WITH P-2
3.000 DIA SF WITH 56145D168, PT. I
.06
.125
6.500
1 COVER TUBE
.75 .062 SF PTS 1 & 2
.187 S.F. WITH PTS 1 & 2
3 SEPARATOR
2.500 DIA (REF)
.062 R
DETAIL 'B'
'A'
.75 (REF.)
2.38 DIA
2.13 DIA (REF)
2.500 DIA. SF P.1
.13
.69
6.718
.75
.062 (SYM) SF P-3 (TYP 2 PLACES) 180° APART
SEE DET 'B
15°
37½°
SECTION 'A'-'A'
2 WATER PASSAGE TUBE
NOTE:-
1. BREAK ALL SHARP EDGES
FIGURE 2c
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES-- TOLERANCES ON 2-PLACE DECIMALS ± .01 3-PLACE DECIMALS ± .005 ANGLES ± 0°30' ALL SURFACES 125√
MATERIAL - HIGH CONDUCTIVITY OXYGEN FREE COPPER
SIGNATURES DATE
1-9-63
1-10-64
1-11-64
GENERAL ELECTRIC
MSD-SSL
VALLEY FORGE, PA
TUBE DETAILS
CONTRACT NO
SIZE C DWG NO. 56145C172
SCALE FULL
SHEET OF

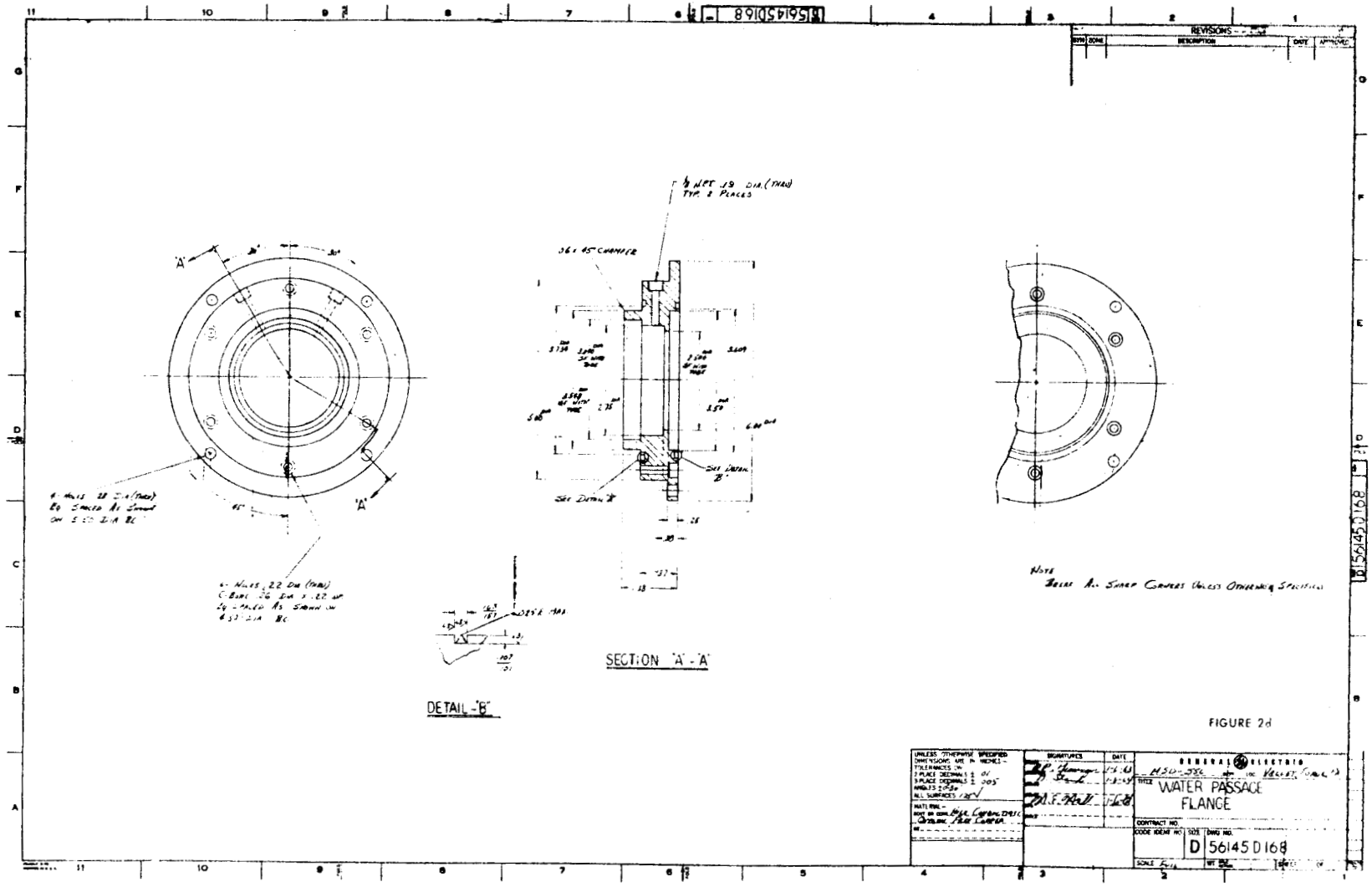

REVISIONS
ZONE
DESCRIPTION
DATE
APPROVED
56145D168
SECTION "A-A"
DETAIL "B"
Note
Break All Sharp Corners Unless Otherwise Specified
WATER PASSAGE FLANGE
D 56145D168

FIGURE 2d

REVISIONS	SIZE 56145B170	REV
SYM	DESCRIPTION	DATE	APPROVAL

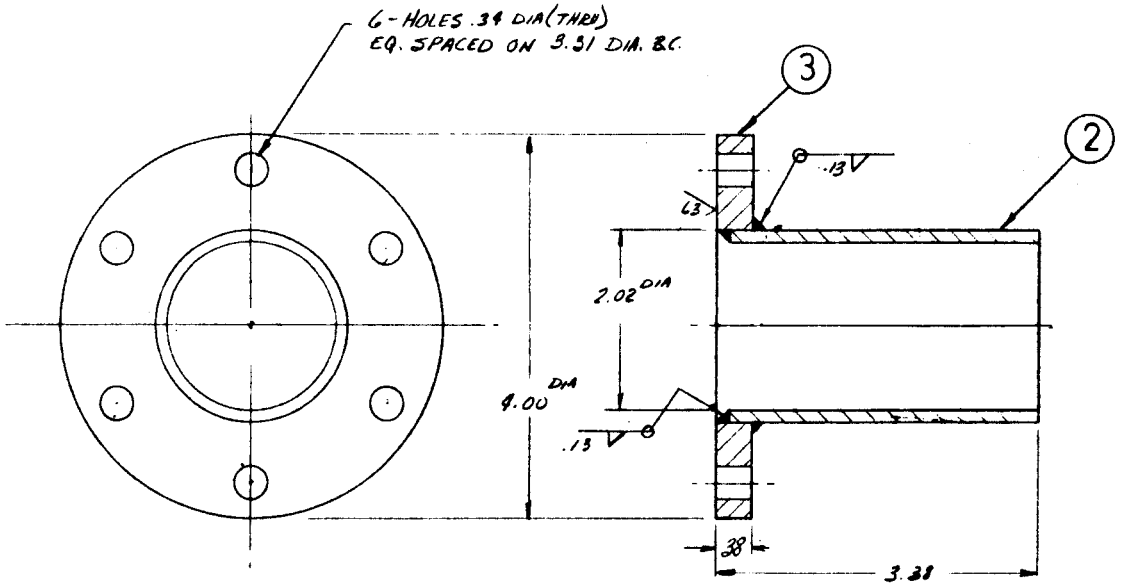


FIGURE 3a

(1) ASSEMBLY

QTY	ITEM	IDENT. NO.	DESCRIPTION	MATERIAL	PRINTS TO
1	3		FLANGE	ALUM. TYPE 2024-T4	
1	2		TUBE 2.00 OD X 1.75 ID X 3.25 LG	ALUM. TYPE 2024-T4	
X	1		ASSEMBLY		

NOTE
1. ALL FINISH MACHINING TO BE DONE AFTER WELDING
2. BREAK ALL SHARP EDGES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON XX DEC. XXX DEC. ANGLES ± .01 ± .005 ± 30' ALL SURFACES 125	DRAWN R.P. Hennigar
	DATE 1-3-68
	APPD. D. Stout 1/7/68
	ISSUED
MATERIAL GOVT. OR COML.	APPROVED ENGR J.E.H. DATE 1/12/68
G-E	MFG
	MATL

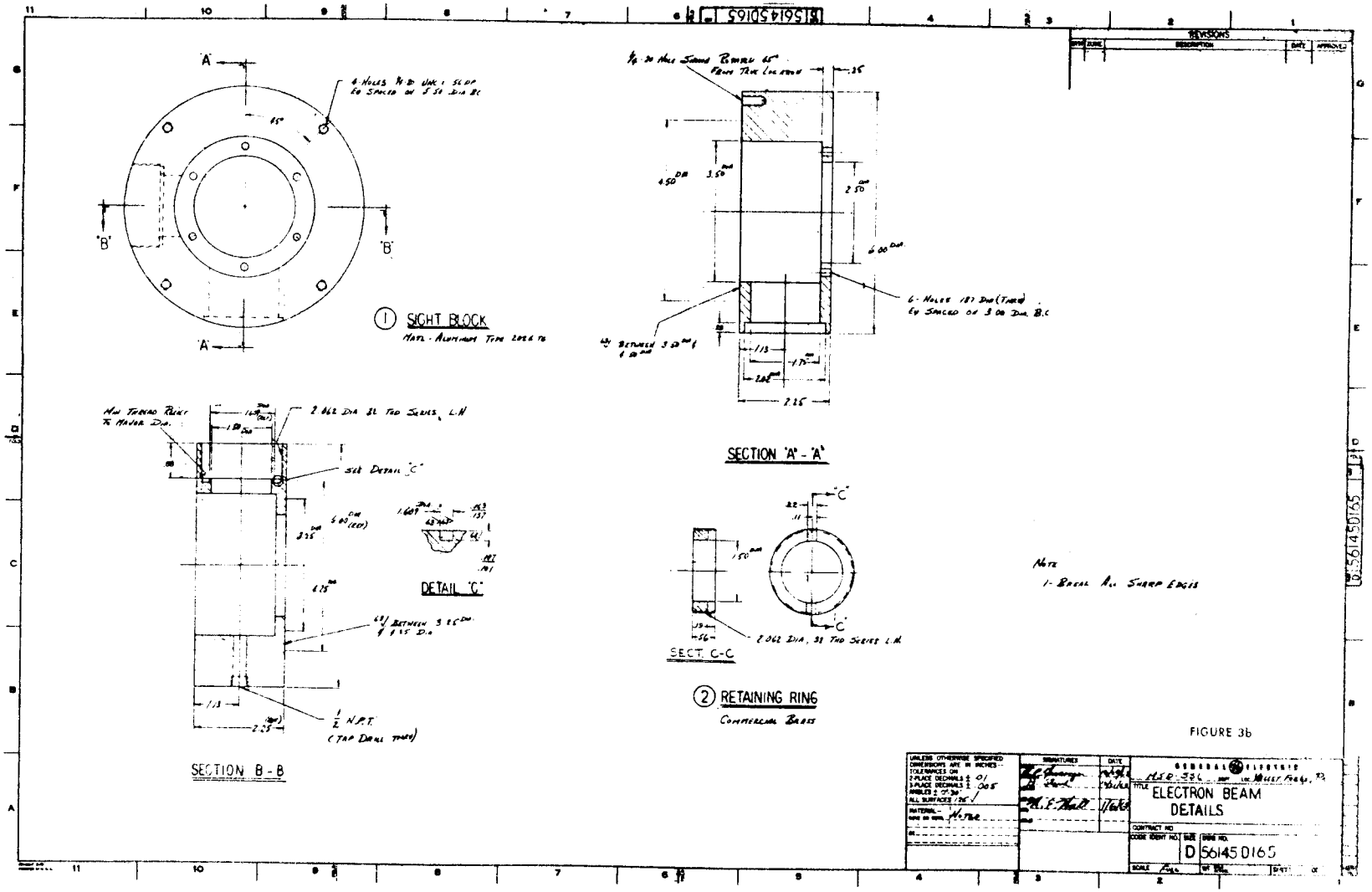
FLANGE ASSEMBLY

SCALE FULL | WT

GENERAL ELECTRIC
MSD 556
DIV OR DEPT
VALLEY FORGE, PA
LOCATION

SIZE 56145B170

CONT ON SHEET | SH NO.



① SIGHT BLOCK

Mats. - Aluminum Type 6061-T6

② RETAINING RING

Commercial Brass

FIGURE 3b

REVISIONS		SIZE 56145 B 159 REV	
		CONT ON SHEET	SH NO.
SYM	DESCRIPTION	DATE	APPROVAL

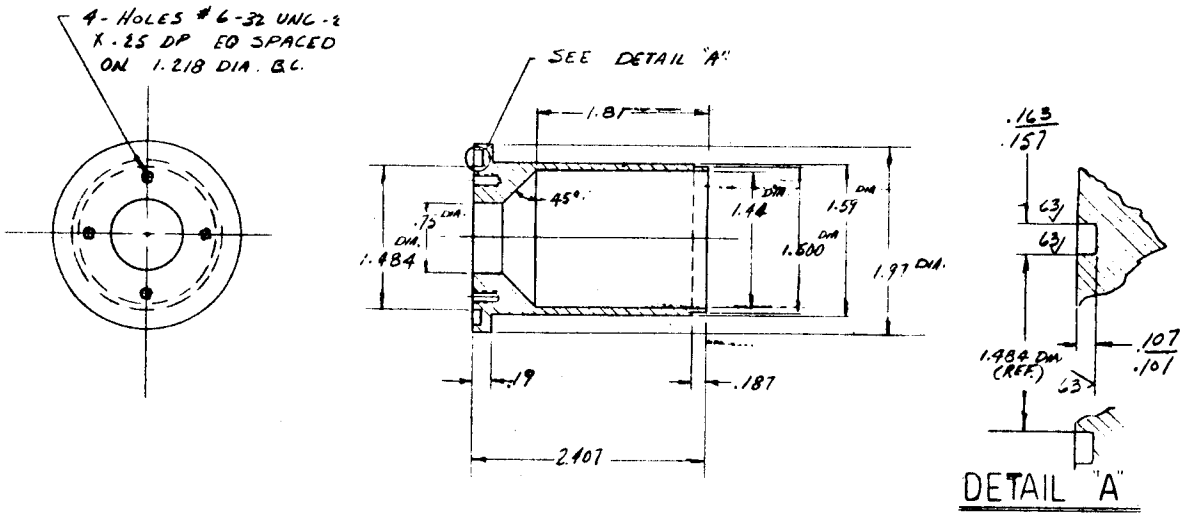


FIGURE 4a

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON	DRAWN RP Jennings	ADAPTER	GENERAL ELECTRIC MSD-55L
XX DEC ±.01 XXX DEC ±.005 ANGLES ±0°30'	DATE		DIV OR DEPT VALLEY FORGE, PA
ALL SURFACES 125 ✓	APPD D. Stark 12/9/66		LOCATION
MATERIAL GOVT. OR COML. STN STL TYPE 304	ISSUED		SIZE 56145B159
G-E	APPROVED / DATE		
	ENGR A.E. Hall 12/9/66		
	MFG		
	MATL	SCALE FULL WT (AS)	CONT ON SHEET SH NO

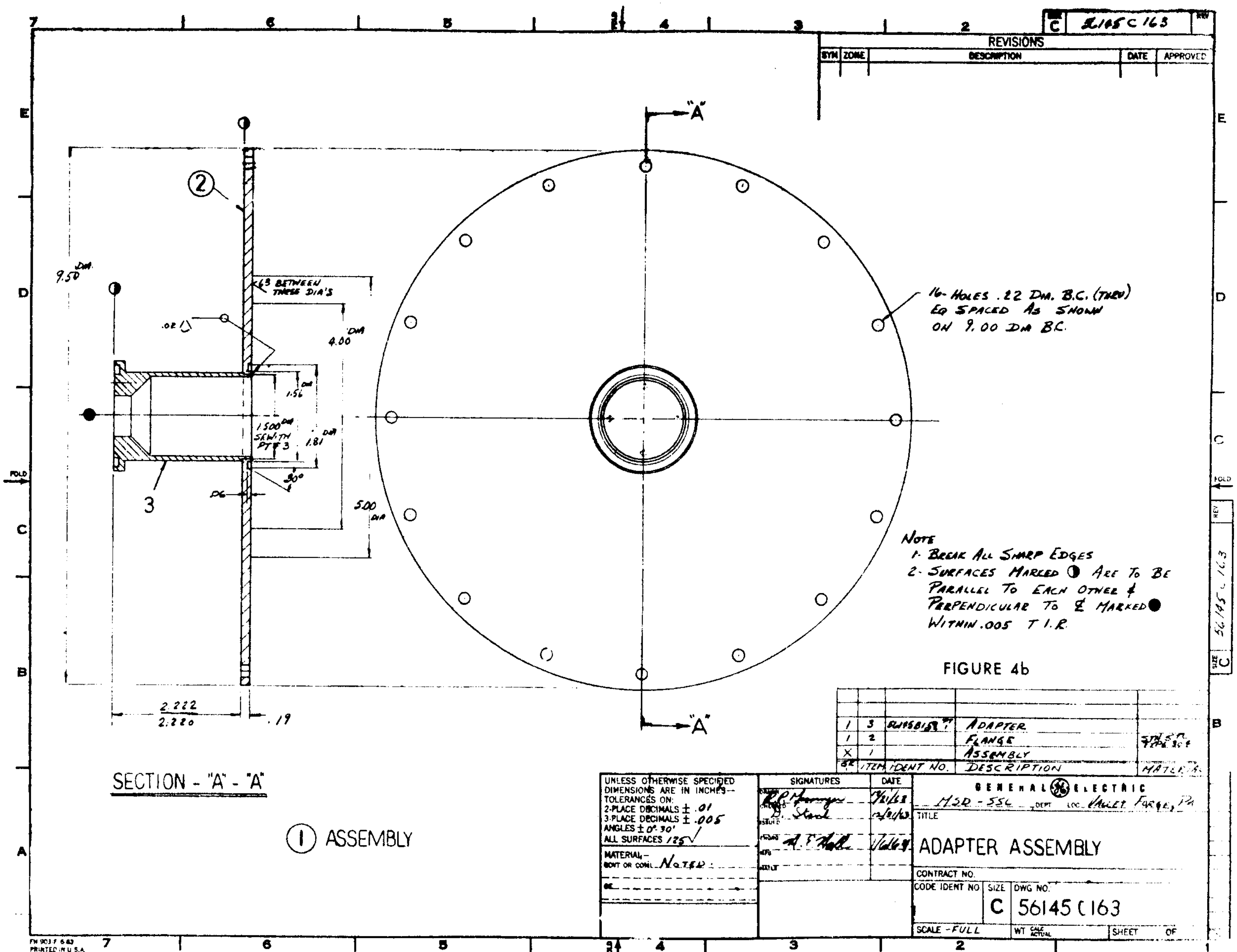

16-HOLES .22 DIA. B.C. (THRU) EQ SPACED AS SHOWN ON 9.00 DIA B.C.
NOTE
1. BREAK ALL SHARP EDGES
2. SURFACES MARKED ◑ ARE TO BE PARALLEL TO EACH OTHER & PERPENDICULAR TO ℄ MARKED ● WITHIN .005 T.I.R.
SECTION - "A" - "A"
① ASSEMBLY
9.50 DIA
4.00 DIA
5.00 DIA
1.56 DIA
1.81 DIA
1.500 DIA SEW WITH PT # 3
63 BETWEEN THESE DIA'S
.02
30°
.06
.19
2.222
2.220
REVISIONS
SYM ZONE DESCRIPTION DATE APPROVED
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
2-PLACE DECIMALS ± .01
3-PLACE DECIMALS ± .005
ANGLES ± 0° 30'
ALL SURFACES 125
MATERIAL - NOTED
SIGNATURES DATE
1 3 ADAPTER
1 2 FLANGE
X 1 ASSEMBLY
ITEM IDENT NO. DESCRIPTION MATERIAL
GENERAL ELECTRIC
MSD - SSL DEPT LOC. VALLEY FORGE, PA
TITLE ADAPTER ASSEMBLY
CONTRACT NO.
CODE IDENT NO SIZE C DWG NO. 56145 C163
SCALE - FULL
WT
SHEET OF

FIGURE 4b

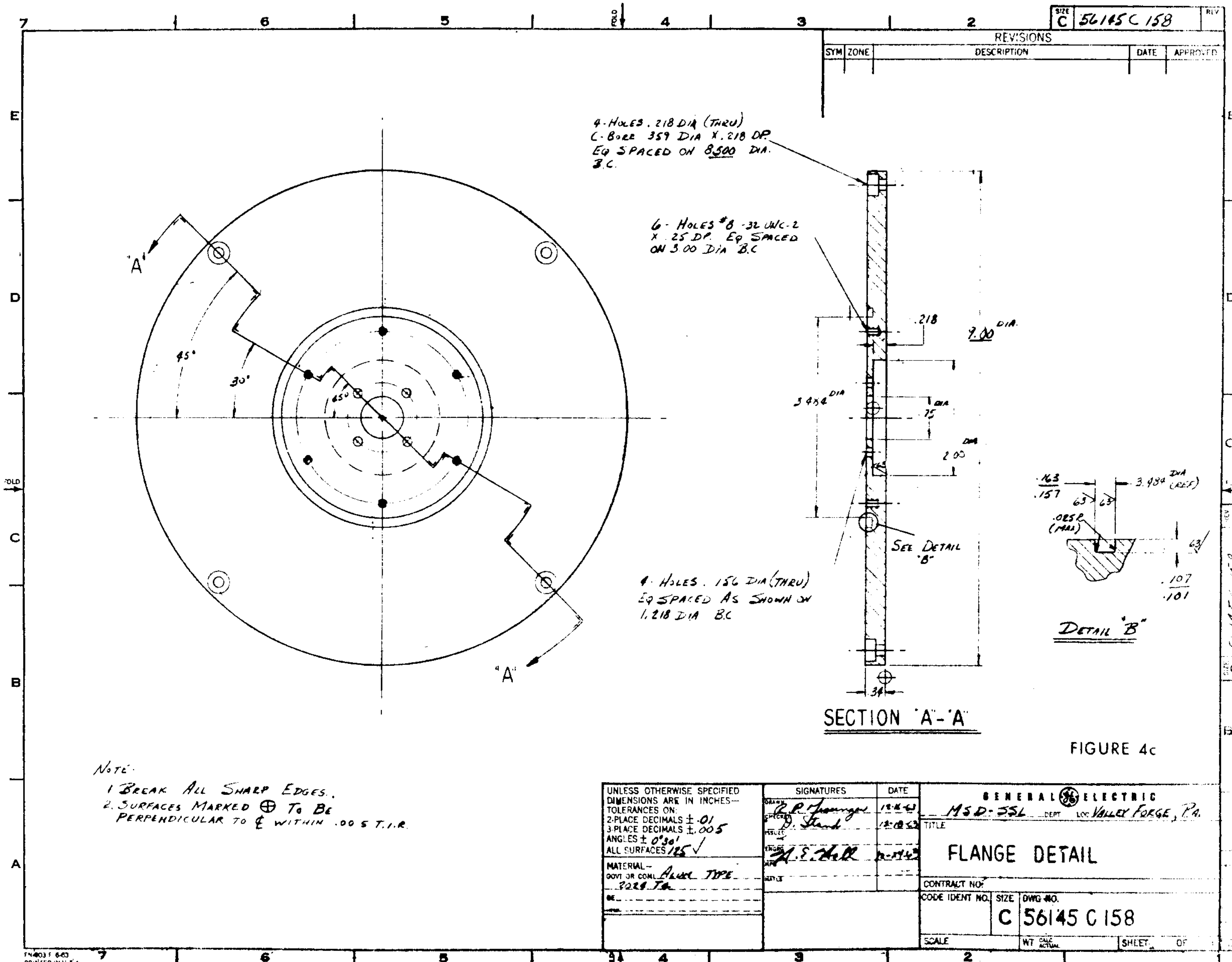

C 56145 C 158
REVISIONS
SYM ZONE DESCRIPTION DATE APPROVED
4-HOLES .218 DIA (THRU) C-BORE .359 DIA X .218 DP. EQ SPACED ON 8.500 DIA. B.C.
6-HOLES #8-32 UNC-2 X .25 DP. EQ SPACED ON 3.00 DIA B.C
4-HOLES .156 DIA (THRU) EQ SPACED AS SHOWN ON 1.218 DIA B.C
'A'
"A"
45°
30°
65°
.218
9.00 DIA.
3.484 DIA
.75 DIA
2.00 DIA
SEE DETAIL "B"
.34
SECTION 'A'-'A'
.163
.157
3.484 DIA (REF)
.025 R (MAX)
.107
.101
DETAIL "B"
NOTE:
1 BREAK ALL SHARP EDGES.
2. SURFACES MARKED ⊕ TO BE PERPENDICULAR TO ℄ WITHIN .005 T.I.R.
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES— TOLERANCES ON: 2-PLACE DECIMALS ± .01 3-PLACE DECIMALS ± .005 ANGLES ± 0°30' ALL SURFACES 125 √
MATERIAL— ALUM. TYPE 2024 T4
SIGNATURES DATE
GENERAL ELECTRIC
MSD-SSL DEPT LOC VALLEY FORGE, PA.
TITLE FLANGE DETAIL
CONTRACT NO.
CODE IDENT NO. SIZE C DWG NO. 56145 C 158
SCALE WT SHEET OF
FN-803 F 6-63 PRINTED IN U.S.A.

FIGURE 4c

REVISIONS	SIZE 56145B160	REV
	CONT ON SHEET	SH NO.

SYM	DESCRIPTION	DATE	APPROVAL

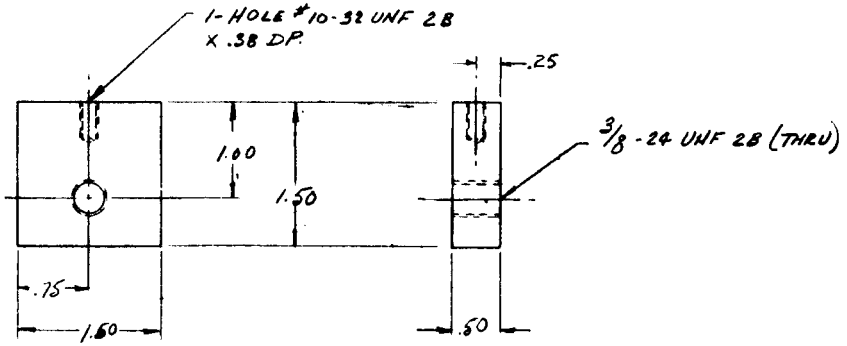


FIGURE 4d

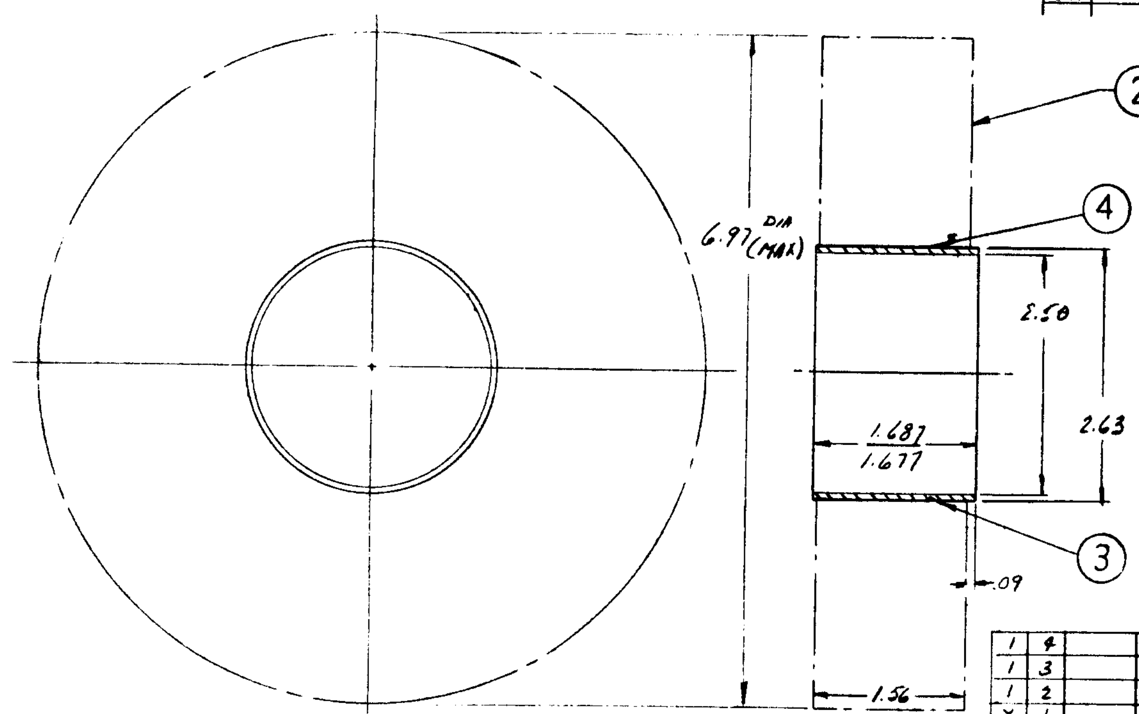
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: XX DEC. ±.01 XXX DEC. ±.005 ANGLES ±0°30' ALL SURFACES 125√	DRAWN R.P. Thompson	ADJUSTING BLOCK	GENERAL ELECTRIC MSD - SSL
MATERIAL GOVT. ~~OR COML~~ CA.#4L. BRASS	DATE 12-17-62		DIV OR DEPT VALLEY FORGE, PA. LOCATION
	APPD D. Stand		
	ISSUED		SIZE 56145B160
	APPROVED / DATE		
	ENGR A.E.H. / 12/20		
	MFG		
	MATL	SCALE FULL WT CALC ACTUAL	CONT ON SHEET SH NO.

PRINTS TO

REV	SH NO.	CONT ON SHEET	SIZE

REVISIONS — SIZE 56122B407 — REV

SYM	DESCRIPTION	DATE	APPROVAL



① ASSEMBLY

NOTE

1 - IMPREGNATE WITH ALUMINA FILLED EPOXY
2: LEADS ARE TO BE 2 FT 0 MIN

FIGURE 5a

QR	ITEM	IDENT NO	DESCRIPTION	MATL
1	4		MYLAR .010 THK	
1	3		TUBE	ALUM 2024-T4
1	2		WINDING	
X	1		ASSEM BLY	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
XX DEC ±.01 XXX DEC ±.005 ANGLES ±30'
ALL SURFACES 125 √
MATERIAL
GOVT. OR COML. NOTED
G-E

DRAWN R.P. Fessenger
DATE 12-30-63
APPD D. Stand 1-15
ISSUED QPM
APPROVED — DATE
ENGR AEK 12/30
MFG
MATL

MAGNET

GENERAL ELECTRIC
MSD - SSL
DIV OR DEPT
VALLEY FORGE PA.
LOCATION
SIZE 56122B407
SCALE FULL — WT FULL
CONT ON SHEET — SH NO.

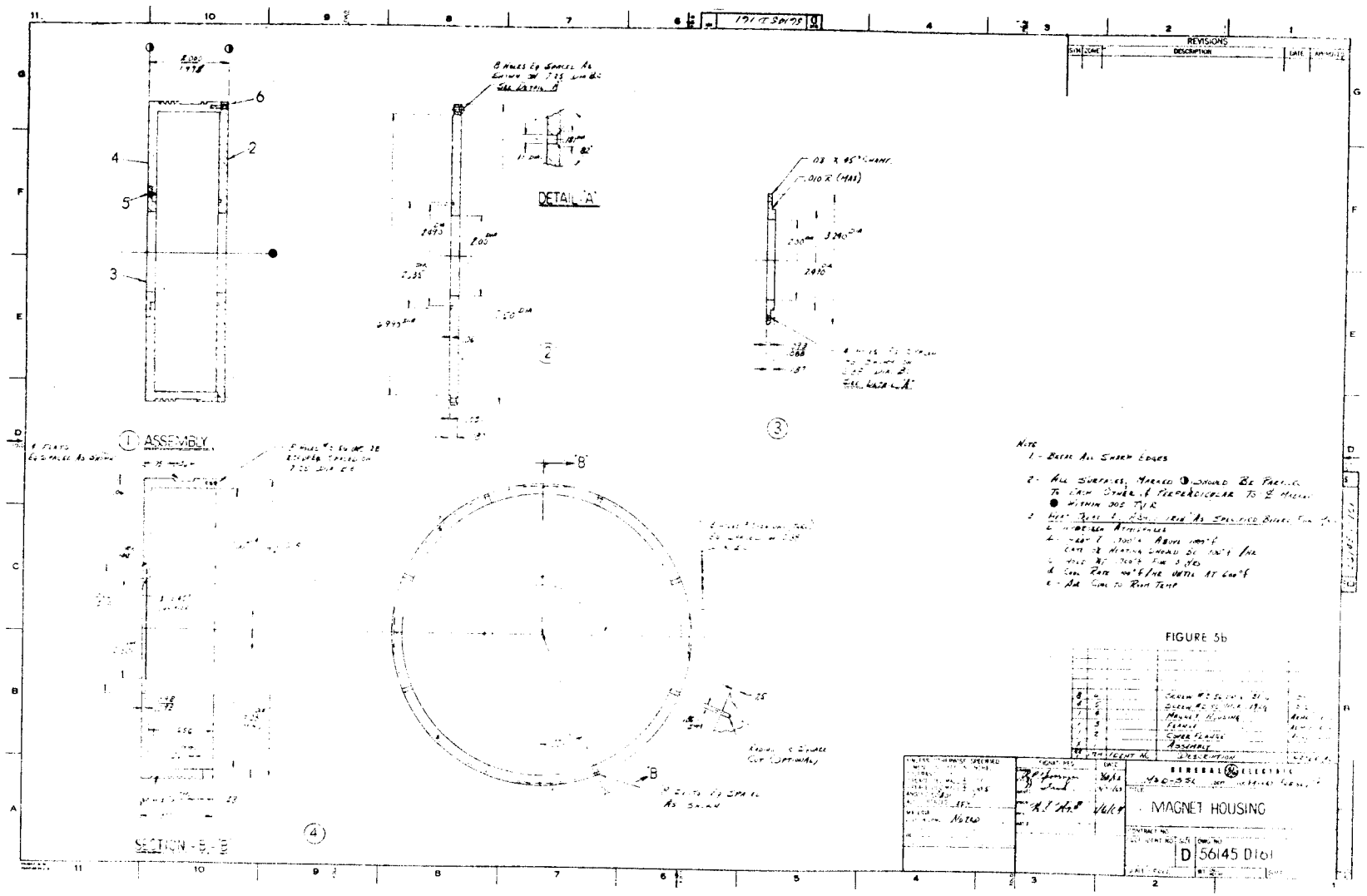

DETAIL "A"
1 ASSEMBLY
2
3
4
SECTION - B - B
REVISIONS
DESCRIPTION
MAGNET HOUSING
D 56145 D101

FIGURE 5b